REMARKS

Reconsideration of the above-identified application in view of the amendments above and the remarks following is respectfully requested.

Claims 62-72 and 74-81 are in this Application. Claims 62-64, 66, 67 and 71-72 have been rejected under 35 U.S.C. § 102. Claims 65, 68-70 and 74-81 have been rejected under 35 U.S.C. § 103. Claims 1-61, 73 and 82-83 have been canceled in a previous response. Claims 65 and 75 have been canceled herewith. Claims 62-63, 66, 69-70, 72, 74, 78-79 and 80 have been amended herewith. New claim 84 has been added herewith.

Amendments To The Claims

35 U.S.C. § 102 Rejections

The Examiner rejected claims 62-64, 66, 67 and 71-72 as being anticipated by US Pat. Appl. 2002/0074499 by Butler (hereinafter *Butler*). It is submitted in response that independent claims 62, 74 and 79, and the claims dependent thereon, are patentable, in the light of arguments set forth below.

The present application addresses the issue of accurately calculating external temperatures based on the output signal of an uncooled, unshielded IR detector having an array of infra-red (IR) sensors.

During camera operation only a small fraction of the energy impending upon the detector comes from the external scene. Camera components such as the optics and housing (also denoted the vacuum package) emit large amounts of energy and are closer to the IR sensors themselves. Additionally, these components irradiate the IR sensors over the entire half planar cone angle of light collection, not just from the relatively small optics which allows entry of energy from the external scene. Small changes in the temperature of the camera components may therefore produce significant changes in the detector output signal.

The signal-to-temperature calculation is performed in a two-step process. First a non-uniformity correction (NUC) is applied, so as to obtain a uniform response from

all the sensors in the array. After non-uniformity correction the response of the infra-red sensor elements is equal, typically within an error significantly smaller than the noise related to the detection of the signal. Only after the uniform outputs are obtained is a respective temperature calculated for each of the IR sensors.

A main problem of translating the IR sensor output signal to temperature is to compensate for the energy emitted by the camera components. This problem is separate from the corrections required due to detector functionality issues, such as non-uniformity between IR sensors.

The goal of the claimed embodiments is to obtain highly accurate temperature values by incorporating the reference shutter temperature and average video signal into the signal-to-temperature calculations. The average video signal is used to obtain a differential measurement for each sensor, which serves as a respective input to the signal-to-temperature function for each individual sensor. The reference shutter temperature serves as an offset of the signal-to-temperature function. This offset does not vary on a sensor-by-sensor basis, but rather is the same for all sensors in the array.

Independent claim 62 is hereby amended to state:

> 1. An infra-red imaging camera comprising:
>
> an uncooled and unshielded detector (14) comprising an array of infra-red (IR) sensors arranged to detect infra red radiated energy,
>
> a non-uniformity corrector, associated with said detector (14), operable to perform non-uniformity correction on outputs of said array to provide uniform outputs having a uniform response to energy detected at said uncooled sensor, and
>
> a calibrator to carry out periodic calibration operations by taking at least one calibration temperature measurement of a temperature of a shutter (22) of said camera while said shutter (22) is closed, using a first temperature sensor (30) located on said shutter (22), and to derive from said at least one calibration temperature measurement a first reference temperature indicative of radiated energy not from an external scene and a reference level comprising an average video signal of said IR sensors at the time of said calibration temperature measurement, and to calculate a temperature of objects in said camera's field of view for each of said sensors from <u>a difference between a respective uniform output of said sensor and said reference level</u>, <u>said temperature being calculated using a same signal to temperature function for each of said sensors, wherein said first reference temperature is an offset of said function</u>.

Similar amendments have been made to claims 74 and 79. Support is found *inter alia* in p. 17 lines 9-19 and in p. 18 line 23-29.

The claimed embodiments incorporate two camera reference values into the signal-to-temperature calculation. Both measured while the shutter is closed. The first value is a reference temperature measured using a temperature sensor mounted on the camera shutter. The second value is the average video signal of the IR sensors, which is determined by averaging the output level of the sensors in the array at the time the shutter temperature is measured. This average video signal reflects the effects of the local camera temperature on the sensor outputs, without intrusion of energy from the external scene.

The two reference values are used during the second step of the temperature calculation process, namely when calculating a respective temperature from each of the uniform sensor outputs. Page 18, lines 23-29 of the instant specification states:

> During the same period of time that the reference pictures are acquired for the NUC updating process, the reference temperature is measured and associated with the average video signal named AS_n. The video signal after NUC and BPR is used for the average calculation.
>
> Subsequently, when the shutter is in the non-obscuring position, the temperature at any point in the detector's field of view can be calculated from:
>
> $T_{i,j} = F(\ p_{i,j} - AS_n\ , E_{i,j}\ , temp\_amb\ , etc) + Reference\_temperature$

where AS_n is the average video signal, $p_{i,j}$ is an individual sensor output after NUC, and *Reference_temperature* is the shutter reference temperature. It is seen from the above equation that a single function is used for the differential sensor outputs $p_{ij} - AS_n$, with the reference temperature serving as an offset.

Butler teaches calibration parameters which are used during the first step of the temperature calculation process, namely during non-uniformity correction. *Butler* para. 0057 cited by the Examiner explicitly states:

> For purposes of this disclosure, ... "calibration parameters" associated with a sensor generally refer to various parameters that may be used for processing output signals from the sensor to adjust for non-uniformities amongst individual radiation detectors of the sensor. (Emphasis added)

Butler teaches two calibration mappings which are periodically created for the detector array, the fine offset map and the gain map. The fine offset map provides a separate offset for each bolometer in the array (see Butler paras. 0062-0063). The

gain map provides a separate gain for each bolometer in the array (see Butler para. 0064). These offset and gain maps are used to adjust the individual bolometer outputs for non-uniformity, as shown in *Butler* Fig. 10. The respective offset correction is added to the output of each bolometer, and the corrected signal is then multiplied by its respective entry in the gain map.

In contrast with the claimed embodiments, *Butler* fails to provide additional correction of the uniform sensor outputs during the signal-to-temperature calculation. Butler does not apply a signal-to-temperature function to the differential sensor outputs $p_{i,j}$ - AS_n with the shutter reference temperature serving as an offset to the calculation, as claimed herein. *Butler* compensates for local camera temperature only for non-uniformity correction.

A non-uniformity correction method that utilizes only gain and offset maps as in *Butler* is based on a linear model. It therefore cannot compensate for the complex energy exchange between the sensor array and the local camera elements which is non-linear. Even if the offset and gain maps are compensated for the ambient temperature, the signal-to-temperature conversion will still be corrupted by the influence of local camera temperature. This influence is exacerbated when a time-dependency is included in the correction in order to account for the changing camera conditions between one calibration measurement to the next. The calculation of view temperature directly from the uniform sensor outputs (i.e. without obtaining a differential measurement) produces an unacceptable error.

The instant specification presents a detailed mathematical model of the energy exchange between the detector and the internal and external sources impinging upon it (see *inter alia* paras. 0152-0185 of the instant specification). This model is then developed to demonstrate exemplary embodiments for function F(..), which may provide a more accurate correction of the influences of the local camera temperature than the linear model implemented in *Butler*.

Claim 66 is hereby amended to state that the temperature sensor located on the housing is used to determine a second reference temperature. The second reference temperature is measured during imaging of the external scene (i.e. with the shutter open), and is a further parameter for the temperature calculations for a respective image. Claim 66 now states:

66. The infra-red imaging camera of claim 62, wherein said calibrator is further configured to measure a respective second reference temperature during an external temperature measurement using a second temperature sensor located on a housing of said camera, wherein said respective second reference temperature is a further parameter of said signal to temperature function for said external temperature measurement.

Support is found *inter alia* in Eqn. 5 of the instant specification, where Td is the current housing temperature and Td_n is the housing temperature during the n-th NUC update process.

The camera housing strongly influences the IR sensor outputs during regular operation. Since the IR sensors are typically very sensitive, small changes in the housing temperature may result in significant changes in the IR sensor outputs for each frame. Providing a separate temperature sensor on the camera housing enables compensating for the effects of the housing temperature on the IR sensor outputs on a frame by frame basis, in addition to the correction obtained using the shutter temperature and average video signal measurements.

In summary, Applicant believes that the amendments herein clearly differentiate between the present invention and *Butler*. As claimed, the influence of the internal camera temperature is corrected by using a signal-to-temperature function which explicitly incorporates the reference shutter temperature and the average video signal subtracted from the sensor outputs after NUC. *Butler* relates only to the NUC stage by calculating temperature-dependent fine offset and gain maps, and therefore does not eliminate local camera temperature influences from the final temperature calculation. Specifically *Butler* does not teach calculating a temperature of objects in said camera's field of view for each of said sensors "from a difference between a respective uniform output of said sensor and said reference level, said temperature being calculated using a same signal to temperature function for each of said sensors, wherein said reference temperature is an offset of said function".

Applicant respectfully believes that the Examiner's objections are overcome by the present amendments.

It is believed that the dependent claims are allowable as being dependent on an allowable main claim. The specific objections against the dependent claims are therefore not responded to individually.

35 U.S.C. § 103

For clarity, Applicants are describing the teachings of *Butler*, *Tsuchimoto*, *Everest* and *Frey* individually but are traversing the rejection with respect to the combination of these references, infra. That is, the Applicants are not attacking the references individually, rather addressing the combinations of references as set forth in the instant Office Action.

The Examiner rejected claims 65, 68, 69 and 74-80 under 35 U.S.C. §103(a) as being unpatentable over *Butler* in view of European Pat. Appl. EP 0837600 (herein *Tsuchimoto*). The Examiner states that *Tsuchimoto* teaches measuring the radiation of the camera's closed shutter whose temperature is known by virtue of an attached thermistor in order to correct for non-uniformities amongst the detector elements, and that it would be obvious to a person skilled in the art to apply this feature to the sensors of *Butler*. Neither *Butler* nor *Tsuchimoto*, alone or in combination, disclose "to calculate a temperature of objects in said camera's field of view for each of said sensors from a difference between a respective uniform output of said sensor and said reference level, said temperature being calculated using a same signal to temperature function for each of said sensors, wherein said reference temperature is an offset of said function"". Thus neither *Butler* nor *Tsuchimoto*, alone or in combination, disclose all the limitations of claims 65, 68, 69 and 74-80.

It is therefore submitted that claims 65, 68, 69 and 74-80 are both novel and inventive over the cited prior art.

It is believed that dependent claims are allowable as being dependent on allowable main claims. The specific objections against the dependent claims are therefore not responded to individually.

The Examiner rejected claim 70 under 35 U.S.C. §103(a) as being unpatentable over *Butler* in view of *Tsuchimoto* and further in view of US Pat. 4,907,895 by Everest (herein *Everest*). The Examiner states that *Everest* teaches coating at least part of the internal side of a shutter so that it is highly reflective to the infrared radiation generated by the shutter, and that it would be obvious to a person skilled in the art to apply this to *Butler* as modified by *Tsuchimoto*. Neither *Butler* nor *Tsuchimoto* nor *Everest*, alone or in combination, disclose "to calculate a temperature of objects in said camera's field of view for each of said sensors from a difference between a respective uniform output of said sensor and said reference level, said temperature being calculated using a same signal to temperature function for each of said sensors, wherein said reference temperature is an offset of said function". Thus neither *Butler* nor *Tsuchimoto* nor *Everest*, alone or in combination, disclose all the limitations of claim 70.

It is therefore submitted that claim 70 is both novel and inventive over the cited prior art.

The Examiner rejected claim 81 under 35 U.S.C. §103(a) as being unpatentable over *Butler* in view of *Tsuchimoto* in view of US Pat. 5,925,875 by Frey (herein *Frey*). The Examiner states that *Frey* teaches using a high pass filter in conjunction with a focal plan array in order to remove unwanted temporal noise and fixed pattern noise components of an image signal, and that it would be obvious to a person skilled in the art to apply this feature to the method of *Butler* as modified by *Tsuchimoto*. Neither *Butler* nor *Tsuchimoto* nor *Frey*, alone or in combination, disclose "to calculate a temperature of objects in said camera's field of view for each of said sensors from a difference between a respective uniform output of said sensor and said reference level, said temperature being calculated using a same signal to temperature function for each of said sensors, wherein said reference temperature is an offset of said function"". Thus neither *Butler* nor *Tsuchimoto* nor *Frey*, alone or in combination, disclose all the limitations of claim 81.

It is therefore submitted that claim 81 is both novel and inventive over the cited prior art.

New claim

Claim 84 is hereby added to include the feature of using a housing sensor measurement as a second reference temperature in the signal-to-temperature calculations. Support is found *inter alia* in Eqn. 5 of the instant specification, where Td is the current housing temperature and Td_n is the housing temperature during the n-th NUC update process.

Conclusion

In view of the above amendments and remarks it is respectfully submitted that claims 62-64, 66-72, 74, 76-81 and 84 are now in condition for allowance. A prompt notice of allowance is respectfully and earnestly solicited.

Respectfully submitted,

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Enclosures:

- Petition for Extension (1 Month)